

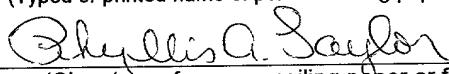
APPLICATION FOR UNITED STATES PATENT

SERVO VALVE EROSION INHIBITED AIRCRAFT HYDRAULIC FLUIDS

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CROSS REFERENCE TO RELATED APPLICATION:

This application claims the benefit of U.S. Provisional Application 60/285,106 filed April 20, 2001.

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SERVO VALVE EROSION INHIBITED AIRCRAFT HYDRAULIC FLUIDSFIELD OF THE INVENTION

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[0001] This invention relates to phosphate ester fluids used in transmitting power in hydraulic systems. More specifically it relates to enhancing the anti-erosion properties of such fluids.

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BACKGROUND OF THE INVENTION

[0002] Functional fluids are used in a wide variety of industrial applications. For example they are used as the power transmitting medium in hydraulic systems, such as aircraft hydraulic systems.

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[0003] Functional fluids intended for use in aircraft hydraulic systems must meet stringent performance criteria such as thermal stability, fire resistance, low susceptibility to viscosity changes over a wide range of temperatures, good hydrolytic stability, elastomer compatibility and good lubricity.

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[0004] Organic phosphate ester fluids have been recognized as a preferred fluid for use as a functional fluid such as in hydraulic fluids. Indeed, in present commercial aircraft hydraulic fluids phosphate esters are among the most commonly used base stocks.

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[0005] As with other functional fluids, organic phosphate ester based fluids require the incorporation of various additives to enhance the performance of the fluid. For example, experience has shown that orifices in the servo control valves of aircraft hydraulic systems are subject to erosion which is attributed to

streaming current induced by fluid flow. Valve orifice erosion, if extensive, can greatly impair the functioning of the valve as a precise control mechanism. Therefore various additives have been used in functional fluids as erosion inhibitors. Nonetheless, there remains a need for increased choice of useful erosion inhibitors, especially for improved erosion inhibitors.

[0006] One object of the present invention is to provide phosphate ester based aircraft hydraulic fluids with enhanced anti-erosion properties.

10 SUMMARY OF THE INVENTION

[0007] Briefly stated a phosphate ester functional fluid, especially a hydraulic fluid, is enhanced by incorporating in the fluid an erosion inhibiting an erosion inhibiting amount of an additive or mixture thereof having the formula



where $R_f = F(CH_2CF_2)_y$, $y = 1$ to about 9 and M is an alkali metal selected from lithium, sodium, potassium, rubidium or cesium. M can also be a quaternary ammonium cation having following formula $RR'R''R'''N^+$ wherein R, R', R'', R''' are independently hydrogen, hydrocarbyl groups of from 1 to 30 carbon atoms and oxygen containing hydrocarbyl groups of from 1 to 25 carbon atoms.

25 DETAILED DESCRIPTION OF THE INVENTION

[0008] The anti-erosion properties of phosphate ester based functional fluids, especially aircraft hydraulic fluids, are enhanced by adding to the fluid an effective amount of a salt or mixture of salts represented by the formula



where $R_f = F(CH_2CF_2)_y$, $y = 1$ to about 9 and M is an alkali metal selected from lithium, sodium, potassium, rubidium or cesium. M can also be a quaternary ammonium cation having following formula $RR'R''R'''N^+$ wherein R , R' , R'' , R''' are independently hydrogen, hydrocarbyl groups of from 1 to 30 carbon atoms and oxygen containing hydrocarbyl groups of from 1 to 25 carbon atoms.

[0009] The foregoing additives are readily prepared by neutralization of the corresponding acid (i.e., a compound of the above formula except that M is H) with an alkali metal hydroxide or quaternary ammonium hydroxide. Additives of the foregoing formula are also commercially available compounds.

[0010] The anti-erosion additive is incorporated in the phosphate ester basestock in an amount sufficient to enhance the anti-erosive properties of the fluid. Typically the addition comprises from about 0.01 wt% to about 0.5 wt% based on the weight of the basestock.

[0011] Phosphate ester base stocks used in this invention refer to organo-phosphate esters selected from trialkyl phosphate, dialkyl aryl phosphate, alkyl diaryl phosphate and triaryl phosphate that contain from 3 to 8 , preferably from 4 to 5 carbon atoms. Suitable phosphate esters useful in the present invention include, for example, tri-n-butyl phosphate, tri-isobutyl phosphate, n-butyl di-isobutyl phosphate, di-isobutyl n-butyl phosphate, n-butyl diphenyl phosphate, isobutyl diphenyl phosphate, di-n-butyl phenyl phosphate, di-isobutyl phenyl phosphate, tri-n-pentyl phosphate, tri-isopentyl phosphate, triphenyl phosphate, isopropylated triphenyl phosphates, and butylated triphenyl phosphates. Preferably, the trialkyl phosphate esters are those of tri-n-butyl phosphate and tri-isobutyl phosphate.

[0012] The amounts of each type of phosphate ester in the hydraulic fluid can vary depending upon the type of phosphate ester involved. The amount of trialkyl phosphate in the base stock fluid comprises from about 10 wt% to about 100 wt% preferably from about 20 wt% to about 90 wt%. The amount of dialkyl 5 aryl phosphate in the base stock fluid is typically from 0 wt% to 75 wt% preferably from 0 wt% to about 50 wt%. The amount of alkyl diaryl phosphate in the base stock fluid is typically from 0 wt% to 30 wt%, preferably from 0 wt% to 10 wt%. The amount of triaryl phosphate in the base stock fluid is typically from 0 wt% to 20 wt% and preferably from 0 wt% to 15 wt%.

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[0013] The hydraulic fluids of this invention contain from 1 wt% to 20 wt% based on total weight composition of additives selected from one or more antioxidants, acid scavengers, VI improvers, rust inhibitors, defoamers. The use of those conventional additives provides satisfactory hydrolytic, oxidative 15 stability and viscometric properties of the hydraulic fluid compositions under normal and severe conditions found in aircraft hydraulic systems.

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[0014] Antioxidants useful in hydraulic fluid compositions in this invention include, for example, polyphenols, trialkylphenols and di (alkylphenyl) amines, examples of which include bis (3,5-di-tert-butyl-4-hydroxyphenyl) methane, 1,3,5-trimethyl-2,4,6-tris (3,5-di-tert-butyl-4-hydroxyphenyl) benzene, 2,6-di-tert-butyl-4-methylphenol, tetrakis (methylene (3,5-di-tert-butyl-4-hydroxyhydrocinnamate) methane, and di (n-octylphenyl) amine. Typical amounts for each type of antioxidants can be from about 0.1 wt% to 2 wt%.

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[0015] Acid scavengers useful in hydraulic fluid compositions of this invention to neutralize phosphoric acid and dialkyl phosphoric acid produced from the hydrolysis and thermal degradation of the phosphate ester base stocks. Examples of acid scavengers include epoxy compounds such as epoxycyclo-

hexane carboxylates. Typical amounts that can be used as acid scavenger can be from about 1 to about 10 wt% based on the total weight of hydraulic fluid.

EXAMPLE 1

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[0016] This example illustrates the preparation of an additive of the present invention.

[0017] To 100 g of Zonyl® FS-62^① in 750 ml methanol is added 13.1 g of
10 KOH with stirring. The methanol is removed by flushing the solution with
nitrogen at 40°C. The product salt is then dried in a vacuum oven at 70-80°C for
24 hours.

EXAMPLE 2

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[0018] This example is presented to hypothetically illustrate making
functional fluids containing an alkali metal salt of a perfluoroalkylethylene
sulfonate. The following functional fluids can be prepared by incorporating the
particular salt into a tributyl phosphate, triarylphosphate base oil containing
20 conventional VI improver, epoxide acid scavenger, antioxidant rust inhibitor and
difoamer.

^① Zonyl® FS-62 is the tradename for a perfluoroalkylene sulfuric acid sold by Du Pont Inc., Wilmington, Delaware.

TABLE 1

<u>Fluid</u>	<u>Additive Salt</u>	<u>Concentration, wt%</u>
1	Potassium	0.01
2	Lithium	0.5
3	Rubidium	0.01
4	Cesium	0.01
5	Potassium	0.5
6	Lithium	0.1
7	Quaterny Ammonium	0.05
8	Ammonium	0.03